

REMARKS

The Official Action dated September 18, 2007 has been carefully considered. Accordingly, the present Amendment is believed sufficient to place the present application in condition for allowance. Reconsideration is respectfully requested.

By the present amendment, claims 1 and 2 have been canceled from the application. Additionally, independent claim 5 has been amended to more clearly recite that, in the charging step (2), the total number of moles of (i) an alkali metal hydroxide formed with hydrogen sulfide formed upon the dehydration, (ii) the alkali metal hydroxide added prior to the dehydration, and (iii) the alkali metal hydroxide added after the dehydration is controlled to provide 1.00 to 1.09 moles of (i)-(iii) per mol of the charged sulfur source, and the number of moles of (iv) water is controlled to provide 0.5 to 2.0 moles of (iv) per mol of the charged sulfur source. Since these changes are fully supported by the original specification, entry of the present Amendment is warranted and respectfully requested.

Claims 5-16 were rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing particularly point out and distinctly claim the subject matter which applicants regard as the invention. Specifically, the Examiner questioned the charging step (2) in claim 5 and asserted that the phrase “a number of moles of water so as to amount to 1.00 to 1.09 per mol of a sulfur source” is confusing and does not agree with the specification.

This rejection is traversed and reconsideration is respectfully requested. Initially, Applicants note that claim 5 is amended to more clearly recite the total number of mols of (i)-(iii) per mol of the charged sulfur is 1.00 to 1.09, while the mols of water (iv) per mol of the charged sulfur source is 0.5 to 2.0. The Examiner’s attention is directed to the paragraph bridging pages 17 and 18 of the specification (paragraph [0047] of US 2006/0084785 A1) which includes the same language as step (2) in claim 5. Accordingly, claim 5 is definite in

view of the teachings of the specification, and the rejection under 35 U.S.C. §112, second paragraph, has been overcome. Reconsideration is respectfully requested.

Claims 5-16 were rejected under 35 U.S.C. 103 (a) as being unpatentable over Sato et al (JP 2000-191785). The Examiner asserted that Sato et al teach a process for producing a poly(arylene sulfide) by polymerizing a sulfur source and a dihalo-aromatic compound in an organic amine solvent which comprises the steps of dehydration, charging, a first-stage polymerization step and a second-stage polymerization step as claimed, although the Examiner admitted that Sato et al do not explicitly teach that the ratio of alkali-metal hydroxide to the charged sulfur source be between 1.00 and 1.09. The Examiner asserted, nevertheless, that a person having ordinary skill in the art would be motivated to employ ratios which meet the limitations of claim 5 as such ratios correspond to a roughly equal molar amount of alkali metal hydroxide and charged sulfur source.

This rejection is traversed and reconsideration is respectfully requested. More particularly, the process for producing a poly(arylene sulfide) according to the present invention comprises four important process steps which, in combination, provide a poly(arylene sulfide) having a desirable combination of improved properties. Specifically, in the dehydration step (1), an alkali metal hydrosulfide and an alkali metal hydroxide are heated and reacted in a proportion of 0.95 to 1.05 mol of alkali metal hydroxide per mol of the alkali metal hydrosulfide. In the subsequent charging step (2), the total number of mols of (i) alkali metal hydroxide formed with hydrogen sulfide formed upon the dehydration, (ii) the alkali metal hydroxide added prior to the dehydration, and (iii) the alkali metal hydroxide added after the dehydration is 1.00 to 1.09 mols per mol of the charged sulfur source and the mols of water are controlled to provide 0.5 to 2.0 mols of water per mol of the charged sulfur source. Additionally, the polymerization is conducted in the defined first-stage polymerization step (3) and the defined second-stage polymerization step (iv).

The importance of the combination of the defined steps (i)-(iv) in providing a poly(arylene sulfide) polymer product in high yield and having good melt viscosity, low yellowness index, low dimer byproduct, good reactivity with aminosilane coupling agents and low volatility, is demonstrated by the examples and comparative examples set forth in the present specification, the conditions and results of which are summarized in Tables 1 and 2 at pages 38 and 39 of the present specification. More particularly, as shown in Comparative Example 1 of the present specification, when the molar ratio of alkali metal hydroxide to alkali metal hydrosulfide (NaOH/NaSH) in the dehydration step (1) and the molar ratio of alkali metal hydroxide (i)-(iii) to sulfur source (NaOH/available S) in the charging step (2) are both lower than the ranges of claim 5, decomposition occurs in the polymerization step.

As shown in Comparative Example 2, when the molar ratio of NaOH/NaSH in the dehydration step (1) is lower than that required by claim 5, the reactivity of the resultant poly(arylene sulfide) to aminosilane becomes undesirably poor and generation of volatile components is undesirably increased, even when the molar ratio of NaOH/available S (sulfur source) in the charging step (2) is controlled to 1.00, i.e., an equimolar amount.

As shown in Comparative Example 3, when the molar ratio of NaOH/available S in the charging step (2) is 1.10, thereby only slightly exceeding the upper limit value of 1.09 as defined by claim 5, the amount of a secondarily produced dimer (i.e., bis(4-chlorophenyl) sulfide) formed increases, and the generation of a volatile component is also increased, even when the molar ratio of NaOH/NaSH in the dehydration step (1) is controlled to 1.04.

Finally, as shown in Comparative Examples 4 and 5, when a combination of a first-stage polymerization step and a second-stage polymerization step as defined by claim 5 of the present application is not employed, the yellow index (YI value) undesirably increases, the amount of bis(4-chlorophenyl) sulfide undesirably increases, the reactivity to aminosilane undesirably decreases, and the rank of volatile component increases, even when the molar

ratio of NaOH/NaSH in the dehydration step (1) and the molar ratio of NaOH/available S in the charging step (2) are controlled within the respective ranges defined by claim 5.

On the other hand, when the production process employs the various defined conditions of steps (1)-(4) of claim 5, an alkali metal hydrosulfide and an alkali metal hydroxide can be used as materials for a sulfur source to stably conduct a polymerization reaction, whereby a poly(arylene sulfide) which is extremely low in the content of bis(4-chlorophenyl) sulfide dimer, excellent in reactivity to silane coupling agents such as γ -aminopropyltriethoxysilane (i.e., aminosilane), low in volatile matter and good in color tone can be provided as shown in Examples 1 to 3.

Sato et al provide no teaching of the claimed combination of steps, or the improvements provided thereby. That is, Sato et al generally disclose a process for producing a poly(arylene sulfide) by reacting an alkali metal sulfide with a dihalo-aromatic compound in an organic amide solvent, which comprises the steps of (A) heating and reacting a mixture containing the organic amide solvent, the alkali metal sulfide and the alkali metal hydroxide, adding water into the reaction system at a desired point of time between the beginning of the reaction and the completion of the reaction, thereby causing water sufficient to form a liquid-liquid phase separation state composed of a concentrated phase and a dilute phase of a formed polymer to exist, and then continuing the reaction under heating up to completion of the reaction, and (B) recovering the organic amide solvent from a reaction mixture containing the organic amide solvent, the formed polymer, water and a secondarily produced alkali metal halide by evaporation or distillation after completion of the reaction (claim 1). Sato et al also disclose that the polymer may be formed by a process of (1) a first-stage polymerization step and (2) a second-stage polymerization step. A feature of the production process by Sato et al resides in that a phase separation polymerization process of a

poly(arylene sulfide) is combined with a recovery process of an organic amide solvent by evaporation or distillation such as flash.

In the production process by Sato et al, alkali metal sulfide is used as a sulfur source.

Sato et al further state that

“The alkali metal sulfide can be prepared from hydrogen sulfide or an alkali metal hydrosulfide and an alkali metal hydroxide *in situ* in an organic amide solvent.” (paragraph [0018]), and

“When an alkali metal hydrosulfide is used as a sulfur source, an almost equimolar amount of an alkali metal hydroxide is added to react both compounds *in situ* in an organic amide solvent, thereby converting the alkali metal hydrosulfide to an alkali metal sulfide.” (paragraph [0026]).

However, Sato et al do not exemplify any process combining use of the alkali metal hydrosulfide and the alkali metal hydroxide as the sulfur source, particularly in combination with steps (2)-(4) as claimed.

Example 1 of Sato et al shows that a 20-liter autoclave was charged with sodium sulfide (Na_2S) pentahydrate and N-methylpyrrolidone (NMP) to conduct a dehydration step. After the dehydration step, p-dichlorobenzene, NMP and water were charged into the autoclave, and 13.3 g of NaOH having a purity of 97% was added in such a manner that the total amount of NaOH in the autoclave amounted to 6.00 mol% based on the available Na_2S . Thereafter, in Example 1, a first-stage polymerization step and a second-stage polymerization step are successively conducted.

The NaOH is added into the reaction system after the dehydration step in Example 1 of Sato et al so that trace components contained in the alkali metal sulfide are removed or converted to another compound. Specifically, Sato et al state that

“The alkali metal hydroxide is used in combination for reacting with an alkali metal hydrosulfide or an alkali metal thiosulfate, which may be present in a trace amount in the alkali metal sulfide, whereby these trace components can be removed or converted to an alkali metal sulfide.” (paragraph [0018]).

Accordingly, the addition of NaOH after the dehydration step in the production process of Example 1 of Sato et al is limited to the case where the alkali metal sulfide (Na_2S) is used as the sulfur source. In addition, NaOH is added after the dehydration step in the production process of Sato et al so that NaOH is reacted with the alkali metal hydrosulfide and the alkali metal thiosulfate, which may be present in trace amounts in the alkali metal sulfide (Na_2S), not so that a molar ratio of the alkali metal hydroxide (NaOH) to the charged sulfur source (available sulfur source) is controlled. However, Sato et al do not disclose that when a combination of alkali metal hydrosulfide (NaSH) and alkali metal hydroxide (NaOH) is used as the sulfur source in the production process the molar ratio of the alkali metal hydroxide (NaOH) to the charged sulfur source (available sulfur source) is optimized according to step (2) of claim 5.

According to the results of recent researches on polymerization of poly (arylene sulfide), it is inferred that an alkali metal hydroxide (NaOH) reacts with an organic amide solvent by heating in the dehydration step to form an alkali metal alkylaminoalkanoate (i.e., alkylaminoalkylcarboxylate), and this alkali metal alkylaminoalkanoate forms a complex with an alkali metal hydrosulfide (NaSH). As described above, the present form of the alkali metal hydrosulfide (NaSH) after the dehydration step in the case where the combination of the alkali metal hydrosulfide (NaSH) and the alkali metal hydroxide (NaOH) is used as the sulfur source is considered different from the case where the alkali metal sulfide (Na_2S) is used as the sulfur source at present. Therefore, if the molar ratio of the alkali metal hydroxide (NaOH) to the sulfur source existing in the reaction system after the dehydration step is too high, changes in properties of the organic amide solvent may occur and/or abnormal reactions or decomposition reactions tend to occur upon polymerization. In addition, the yield and quality of the resulting polymer are lowered.

In the present invention, in the production process of a poly(arylene sulfide) using a combination of an alkali metal hydrosulfide (NaSH) and an alkali metal hydroxide (NaOH) as a sulfur source, the number of moles of the alkali metal hydroxide per mol of the alkali metal hydrosulfide in a dehydration step is set to a selected narrow range of from 0.95 to 1.05. In addition, the total number of moles of the alkali metal hydroxide per mol of the sulfur source existing in the system after the dehydration step is set to a selected narrow range of from 1.00 to 1.09. The total number of moles of the alkali metal hydroxide includes (i) the number of moles of an alkali metal hydroxide formed with hydrogen sulfide formed upon the dehydration, (ii) the number of moles of an alkali metal hydroxide added prior to the dehydration and (iii) the number of moles of an alkali metal hydroxide added after the dehydration.

Sato et al neither teach nor suggest that when a combination of the alkali metal hydrosulfide (NaSH) and the alkali metal hydroxide (NaOH) is used as the sulfur source, with a molar ratio of the alkali metal hydroxide to the alkali metal hydrosulfide in the dehydration step controlled within a range of from 0.95 to 1.05 as in step (1) of claim 5, and a molar ratio of the alkali metal hydroxide (NaOH) to the charged sulfur source (available sulfur source) after the dehydration step is controlled within a selected range of from 1.00 to 1.09, as in step (2) of claim 5, excellent improvements may be obtained in the resulting poly(arylene sulfide).

In view of the failure of Sato et al to teach or suggest a process which comprises the combination of steps (i)-(iv), which combination Applicants have shown are important in providing a product having a desirable combination of properties, Sato et al do not render the process of claim 5, or claims 6-16 dependent thereon, obvious. Moreover, even if the Examiner remains of the opinion that a prima facie case of obviousness has been established based on Sato et al, the Examples and Comparative Examples set forth in the present

specification rebut any such prima facie case of obviousness. As discussed in detail above, the Examples and Comparative Examples in the present specification demonstrate that even if one of steps (i)-(iv) are omitted, a poly(arylene sulfide) of inferior properties is produced. The improvements provided by the present processes are unexpected in view of the teachings of Sato et al. When an applicant demonstrates substantially improved results and states that the results were unexpected, this should suffice to establish unexpected results in the absence of evidence to the contrary, *In re Soni*, 34 U.S.P.Q. 2d 1684, 1688 (Fed. Cir. 1995). Further, a prima facie case of obviousness can be rebutted by evidence of unexpected results, *In re Davis*, 177 U.S.P.Q. 381 (C.C.P.A. 1973). Accordingly, the processes of claims 5-16 are nonobvious over and patentably distinguishable from Sato et al, and the rejection under 35 U.S.C. §103 has been overcome. Reconsideration is respectfully requested.

Claims 1 and 2 were rejected under U.S.C. 103 (a) as being unpatentable over Sato et al. As claims 1 and 2 have been canceled from the application, the rejections of claims 1 and 2 are now moot.

Finally, claims 3 and 4 were rejected under U.S.C. 103 (a) as being unpatentable over Sato et al. The Examiner asserted that the poly(arylene sulfide) taught by Sato et al is produced in substantially the same manner as that described in the present application for the poly(arylene sulfide) of claims 3 and 4. The Examiner therefore concluded that the physical properties of the Sato et al product would be substantially the same as that claimed.

This rejection is traversed and reconsideration is respectfully requested. That is, as discussed in detail above, and as demonstrated in the Examples and Comparative Examples in the present application, a production process containing steps (1)-(4) in combination is required in order for the polymer to contain a bis(4-chlorophenyl) sulfide content lower than 50 ppm as determined by a gas chromatographic analysis. Further, the process of claim 5 provides a polymer in which a ratio (MV2/MV1) of a melt viscosity value (MV2) of the

poly(arylene sulfide) after a reaction with aminosilane to a melt viscosity value (MV1) before the reaction exceeding 2.0 as measured at a temperature of 310°C and a shear rate of 1,216 sec⁻¹, and a yellow index of at most 10.

As also discussed above, Sato et al fail to teach the production process according to the present invention. Sato et al also fail to suggest that a poly(arylene sulfide) having the combination of the specific various properties described above can be obtained by the production process according to the present invention. As Sato et al do not specifically teach a production process according to claim 5 containing steps (i)-(iv), and Applicants have demonstrated that omission of either step (1) or step (2) fails to provide a poly(arylene sulfide) having a bis(4-chlorophenyl) sulfide content lower than 50 ppm as required in claim 3, there is no basis to assert that the properties of claim 3 are inherent in the polymer products of Sato et al. Accordingly, the poly(arylene sulfide)s defined by claims 3 and 4 are nonobvious over and patentably distinguishable from Sato et al, and the rejection under 35 U.S.C. §103 has been overcome. Reconsideration is respectfully requested.

It is believed that the above represents a complete response to the Official Action and places the present application in condition for allowance. Reconsideration and an early allowance are requested.

Please charge any fees required in connection with the present communication, or credit any overpayment, to Deposit Account No. 04-1133.

Respectfully submitted,

/Holly D. Kozlowski/

Holly D. Kozlowski, Reg. No. 30,468
Dinsmore & Shohl LLP
1900 Chemed Center
255 East Fifth Street
Cincinnati, Ohio 45202
(513) 977-8568